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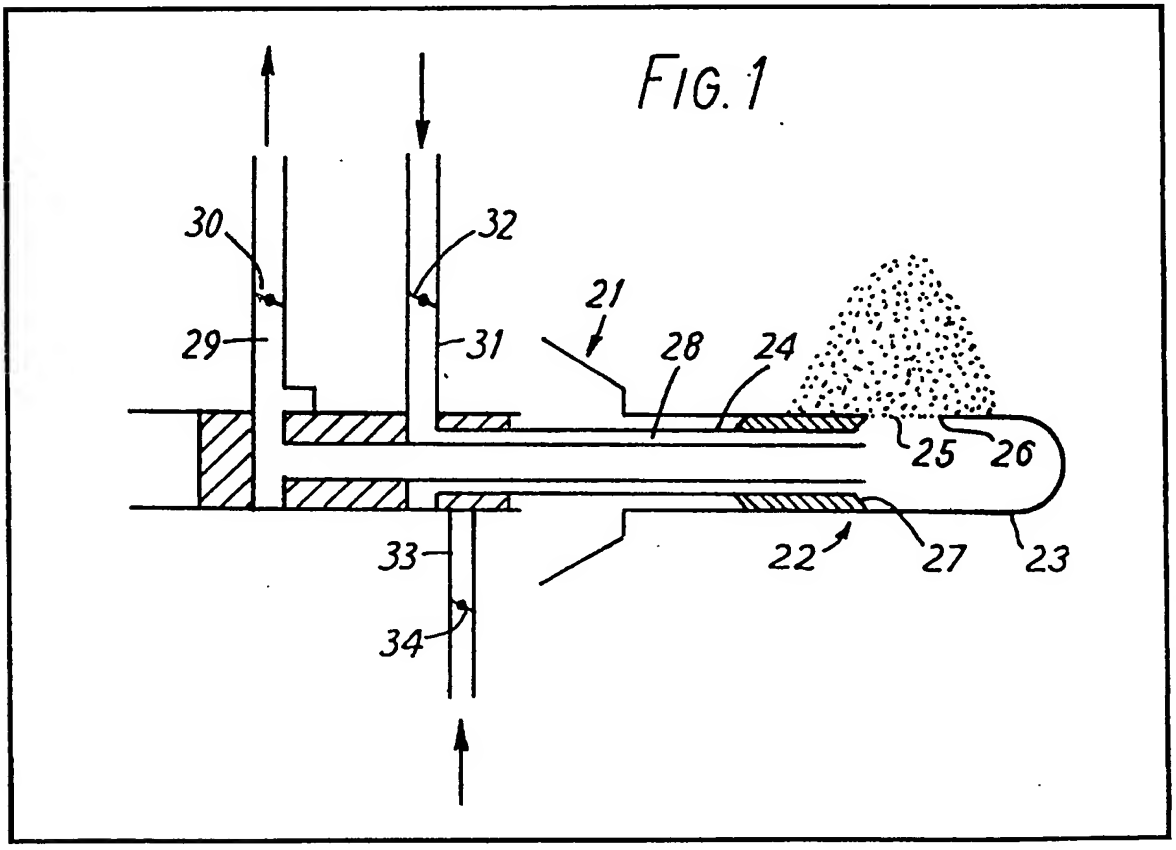
(54) Surgical cutting apparatus

(57) An instrument for the cutting of material, particularly vitreous material comprises a first elongate hollow member 23 having a lateral aperture 25 delimited by a first cutting edge 26, and a second elongate hollow member 24 having a second cutting edge 27, the second member being situated in the first member and being longitudinally displaceable relative thereto so as to cause the edges to cut material positioned between them. The instrument may include a controllable vacuum inlet 29 so that the portion of the material to be cut off may be sucked into the instrument before cutting, may include a purging fluid inlet 33 and may also include an infusion fluid inlet 31.



SPECIFICATION

A method and an instrument for the cutting of vitreous material

This invention relates to a method and an instrument, particularly for the cutting of vitreous, and jelly-like material, especially, though not exclusively, for use in microsurgery.

Because of the special application of the device to ophthalmic microsurgery, the background problem to, and object of, the invention will be discussed in this context, without however thereby suggesting or implying any limitation in the scope of the invention thereto.

In the course of certain operations within an eye, the material thereat, though of jelly-like appearance, is very difficult to cut, mainly because it is made up of a matting of extremely small transparent fibres. The employment of cutting devices for this material presently available results in only approximately 40% of patients recovering their sight, the remainder being rendered permanently blind mainly as a result of their retinas becoming detached.

Such prior art cutting devices involve a scissor action in that at least one of two co-operating cutting edges is drawn across the material to be cut. Some such devices employ rotary cutters which, when they become blunt, tend to catch the vitreous material at the back of the eye, thereby tending to pull the retina away from it.

It is an object of the present invention to provide a cutting device in which, when it is, in its preferred form, applied to the aforesaid microsurgical purpose, the disadvantages of cutting devices previously used for this purpose, as hereinbefore discussed, are substantially reduced or eliminated.

A method for the cutting of material, particularly vitreous material, in which a portion of the material to be cut is brought into an aperture in a first elongate hollow member, the aperture having a first cutting edge, and cut by the movement of a second cutting edge carried by a second elongate hollow member which is situated inside and is longitudinally displaceable relative to the first member. Preferably the portion to be cut is sucked through the said aperture into the instrument by vacuum. The cut portion may be removed from the instrument by a fluid, i.e. a gaseous or liquid medium.

The invention also provides an instrument for the cutting of material, particularly vitreous material, comprising an outer elongate hollow member provided with a lateral aperture partly defined by a first cutting edge, and an inner elongate hollow member having a second cutting edge, the inner member being situated in the outer member and being longitudinally displaceable relative thereto by drive means so as to cause the edges to cut materialy positioned between them.

Preferably the instrument includes conduits communicating with vacuum means so that vacuum may be produced inside the instrument whereby the portion of the material to be cut off may be sucked into the instrument before cutting. The vacuum may be controlled by valve means and/or steplessly by the fingertip of the user of the instrument.

The instrument may include a conduit controlled by valve means and communicating with purging means and may be so designed that the aperture, after completed cutting, remains for a preselected period covered and the purging means floods the instrument with a purging fluid which also floods out the cut-off portion.

Manually operated, program operated and/or automatically operated control means are provided for the actuation of the instrument.

The instrument may also include infusion means whereby the instrument is flooded with an infusion fluid, which may be the same as the purging fluid, the instrument being preferably so designed that the infusion takes place after the aperture has been uncovered, so that the infusion fluid reaches the material from which the said portion was cut off.

The relative displacement of the said members is caused by drive means, which may include a hydraulic, pneumatic, electrical or electromagnetic means. In a preferred embodiment the drive means include an electric motor, which may be a rotatable or linear motor. Preferably the motor is combined with transmission means, whereby the second member, and consequently the second cutting edge, is turned to a preselected degree after each cut, so that the edge is uniformly worn off.

Advantageously the instrument is controlled by a combination of automatic valves and valves controlled manually or by a programme.

One form of an instrument according to the invention, viz. a microsurgical cutting instrument suitable for use in the performance of an ophthalmic operation at the back of an eye, will now be described, by way of example, with reference to the accompanying diagrammatic drawings, in which:

Figure 1 shows the instrument in diagrammatic longitudinal section in position for use,

Figure 2 shows the instrument with vacuum applied to the cutting head thereof,

Figure 3 shows the instrument after completed cutting,

Figure 4 shows the instrument while being purged with saline, whereby the cut-off part is flooded out,

Figure 5 shows the instrument at the beginning of saline infusion,

Figure 6 shows the instrument when the saline infusion is advanced,

Figure 7 shows one embodiment of the driving means and vacuum and saline control means inside the handle of the instrument,

Figure 8 shows a different embodiment of the vacuum and saline control means inside the handle, and

Figure 9 shows the instrument in side view together with a diagram of the control means outside the handle.

Referring to the drawings, the instrument has a handle 21 to be held in the surgeon's hand, and a cutting head 22 projecting from the handle 1 at the front end of the latter.

The cutting head 22 comprises a stationary outer tubular member 23 inside which is coaxially situated an inner tubular member 24 which is reciprocable by means to be described later between a front position and a rear position.

The outer member 23 is closed at its front end and has an aperture 25 which is transverse to the axis of the member 23 and the edge of which provides a first cutting edge 26.

The inner member 24 is provided at its front end with a second cutting edge 27 and includes one or more channels 28 (hereinafter channel 28).

The inside of the inner member 24 communicates with a vacuum conduit 29 controlled by a first valve 30. The channel 28 communicates (in the rear position of the member 24) with a saline infusion conduit 31 controlled by a second valve 32 and (in the front position of the member 24) with a saline purge conduit 33 controlled by a third valve 34.

When the device according to the invention is used e.g. for ophthalmic microsurgery, the cutting head 22 is so positioned that the vitreous substance to be cut therewith is adjacent to the aperture 25 while the member 24 is in its rear position (Fig. 1).

Then the first valve 30 is opened whereby the inside of the inner member 24 is connected to the vacuum conduit 29 so that vacuum prevails inside the member 24 and also in the front part of the member 23, whereby that part of the vitreous substance to be cut off is "sucked" through the aperture 25 into the front part of the member 23 (Fig. 2).

After that the inner member 24 is forced to its front position whereby the cutting edge 27 in cooperation with the cutting edge 26 cuts off the part of the vitreous substance extending through the aperture 25, and the cut-off part remains in the front part of the member 23, while the aperture 25 is covered by the member 24 and/or the cutting edge 27 (Fig. 3).

Following that, the third valve 34 is opened and saline flows under pressure from the purge conduit 33 through the channel 28 into the front part of the member 23 and flows out through the inside of the member 24, whereby the cut-off part is flooded out through the member 24 (Fig. 4). A non-return valve (not shown) in the infusion conduit 31 prohibits saline from the purge conduit 33 from flowing into the infusion conduit 31.

Then the valves 30 and 34 are closed and the second valve 32 is opened whereby saline is infused from the infusion conduit 31 through the channel 28 into the front part of the member 23 and penetrates through the aperture 25, which has been uncovered due to the member 24 being withdrawn to its rear position, to the wound caused by the cutting and washes it (Fig. 5). The infusion pressure may be a constant with an on/off switch under foot control, and the rate of flow may be controlled by the level of vacuum.

The saline is then removed through the inside of the member 24 (Fig. 6).

The member 24 is reciprocated by drive means 35, which in the embodiment shown in Fig. 7 is a rotatable motor combined with a gearbox, co-operating with a cam 36 which in turn co-operates with a follower 37 which will be referred to later. Also other driving means may be used, e.g. a linear motor.

The cam 36 allows the member 24, and consequently the cutting edge 27, slowly to rotate as the instrument is being used, thus ensuring that the cutting edge 27 is worn uniformly. The rotation is obtainable even if a linear motor is used.

In Figs. 1 to 6 the valves 30, 32 and 34 were illustrated for simplicity as butterfly valves. In a preferred embodiment the valves are spool valves 38 connected to and movable with the inner member 24 (Figs. 7 and 8).

In the embodiment shown in Fig. 7 vacuum is applied to the vacuum conduit 29 continuously. The surgeon may increase or decrease the vacuum prevailing inside the member 24 by the degree to which his finger covers a fingerhole 39 in the handle 21. Alternatively the vacuum may be switched ON or OFF by the use of a push button of foot control.

Means for controlling an instrument according to the invention are shown in Fig. 9.

A vacuum pipe S includes an automatic drain filter 1, a two-position solenoid valve 2 and a vacuum pump and reservoir 3.

A pipe U for the saline used for purging and a pipe V for the saline used for infusion are connected to a variable by-pass solenoid valve 4 to which is connected a main saline delivery pipe which includes a hydraulic accumulator 5, a pressure controller 6, a hydraulic pump 7 and a hydraulic reservoir 8.

A motor master ON-OFF circuit R and a motor control circuit T are connected to an electronic circuit board 9, which in turn is connected to a main control panel 10.

The motor (drive means 35) is controlled by an ON-OFF master switch 11 actuated by the surgeon's finger.

The panel 10 provides motor control, vacuum control, low pressure infusion control (and pressure control), and high pressure purge control. The motor speed control may be programmed, the program being required to permit the surgeon: to vary the cutting rate from single stroke, as and when required, up to 9 strokes per second, to increase or decrease the dwell times at either end of the stroke, and to increase or decrease either the cutting speed or return speed or both.

The position of the drive motor is sensed electronically and when a predetermined position is reached the purge pressure is switched on at the control panel 10. Similarly a point of movement is sensed to switch off purge pressure, hence there is a double safeguard.

In its application to ophthalmic microsurgery the handle 21 may have an external diameter of about 25 mm and length of about 130 mm, while the cutting head 22 outside the handle 21 is about 40 mm long. The vacuum is preferably as high as practicable, e.g. 10^{-1} torr (13.3 Pa), the pressure of the purging saline may be e.g. 30 to 45 p.s.i. (205 – 308 kPA), and the pressure of the infusion saline is so high as to maintain satisfactory pressure within the eye, the pressure being nominally about 30 mmHg (4 kPa) and at the most 80 mmHg (10.7 kPa).

The instrument can enable a number of operations to be carried out using the cutter. For that reason the cutting head will be exchangeable or possibly disposable, and different size and/or shape of the aperture 25 can be used for different purposes.

CLAIMS

1. A method for the cutting of material particularly vitreous material, in which a portion of the material to be cut is brought into an aperture in a first elongate hollow member, the aperture having a first cutting edge, and cut by the movement of a second cutting edge carried by a second elongate hollow member which is situated inside and is longitudinally displaceable relative to the first member.

2. A method according to Claim 1 wherein the portion to be cut is sucked through the said aperture into the instrument by vacuum.

3. A method according to Claim 1 or 2 wherein the cut portion is removed from the instrument by a gaseous or liquid medium.

4. A method for the cutting of material, particularly vitreous material, substantially as herein described with reference to the accompanying drawings.

5. An instrument for the cutting of material, particularly vitreous material, comprising an outer elongate hollow member provided with a lateral aperture partly defined by a first cutting edge, and an inner elongate hollow member having a second cutting edge, the inner member being situated in the outer member and being longitudinally displaceable relative thereto by drive means so as to cause the edges to cut material positioned between them.

6. An instrument according to Claim 5 including a conduit communicating with vacuum means so that vacuum may be produced inside the instrument whereby the portion of the material to be cut off may be sucked into the instrument before cutting.

7. An instrument according to Claim 6 wherein the vacuum conduit is controlled by valve means.

8. An instrument according to Claim 6 or 7 including means whereby the vacuum may be controlled steplessly by the fingertip of the user of the instrument.

9. An instrument according to any one of Claims 5 to 8 including a conduit controlled by valve means and communicating with purging means, the instrument being so designed that the aperture, after completed cutting, remains for a preselected period covered and the purging means floods the instrument with a purging fluid which also floods out the cut-off portion.

10. An instrument according to any one of Claims 6 to 9 wherein both the elongate members are substantially tubular, the inner member forming part of the vacuum conduit.

11. An instrument according to any one of Claims 8 to 10 wherein the inner member includes at least one channel forming part of the conduit communicating with the purging means.

12. An instrument according to any one of Claims 9 to 11 wherein the second cutting edge is substantially circular, the drive means being designed to turn the second cutting edge through a predetermined angle after each cut so that each two successive cuts are made by different portions of the second cutting edge.

13. An instrument according to any one of Claims 6 to 12 wherein the valve means are formed by at least one spool valve.

14. An instrument for the cutting of material, particularly vitreous material, constructed, adapted and arranged to operate substantially as herein described with reference to, and as shown in, the accompanying drawings.

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FIG. 1

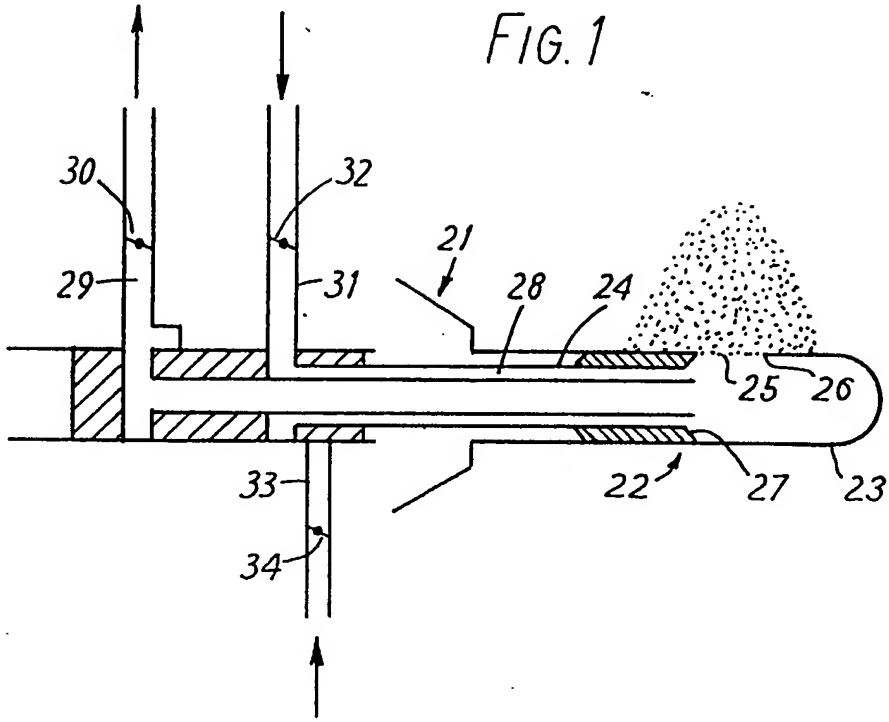

FIG. 2

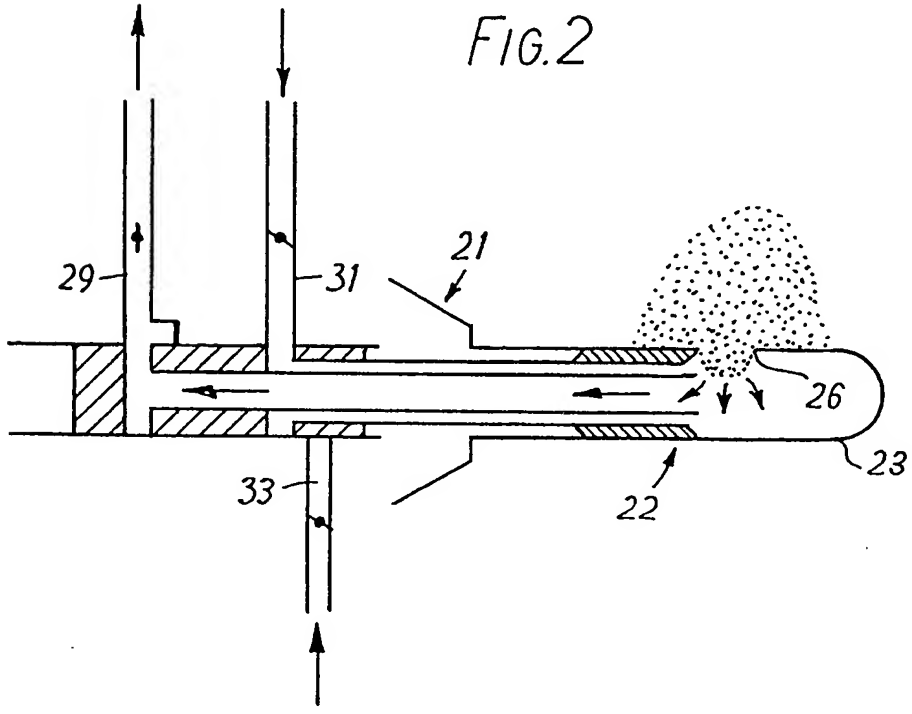

FIG. 3

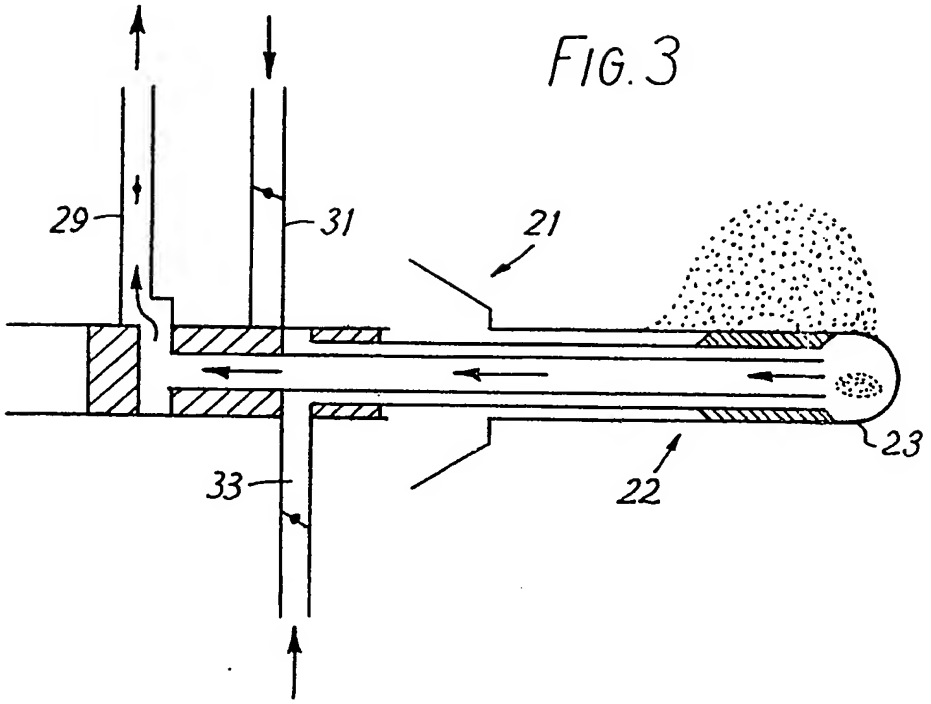

FIG. 4

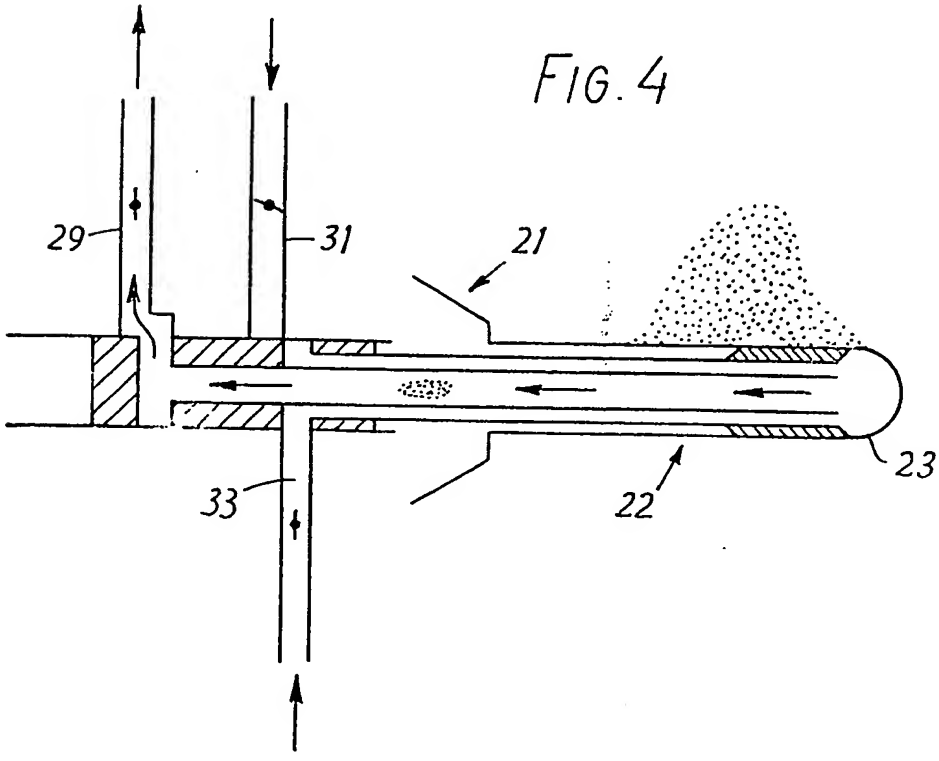

FIG.5

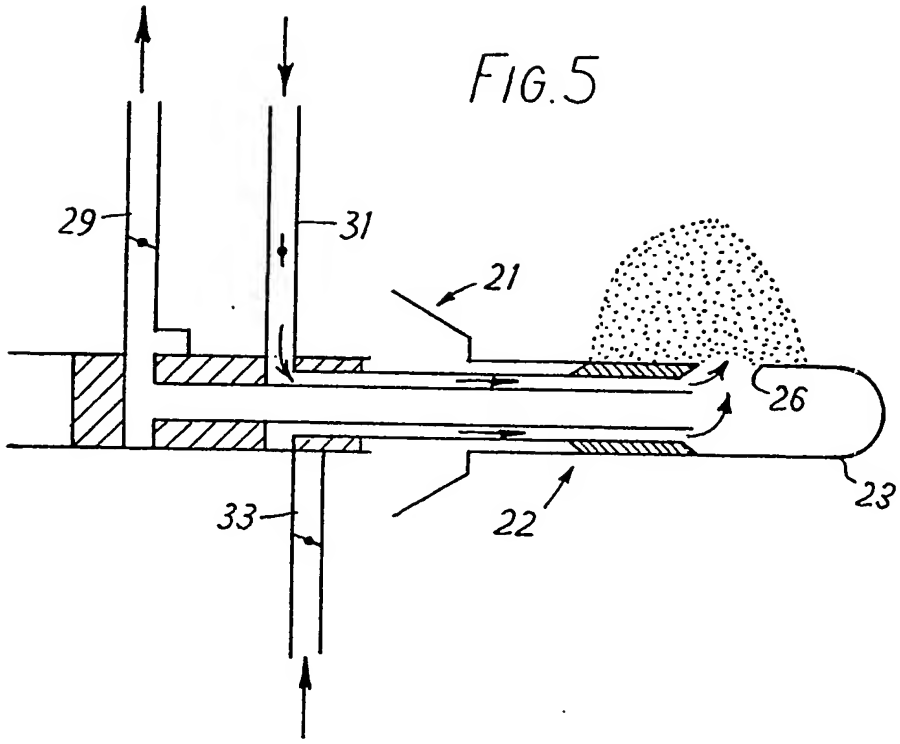

FIG.6

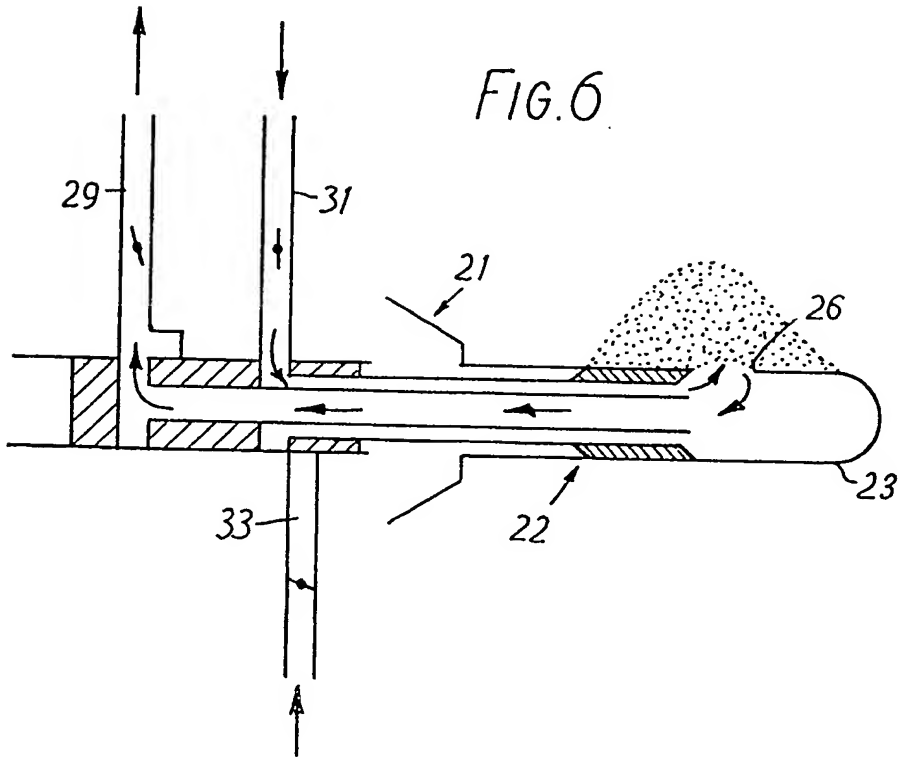

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FIG. 7

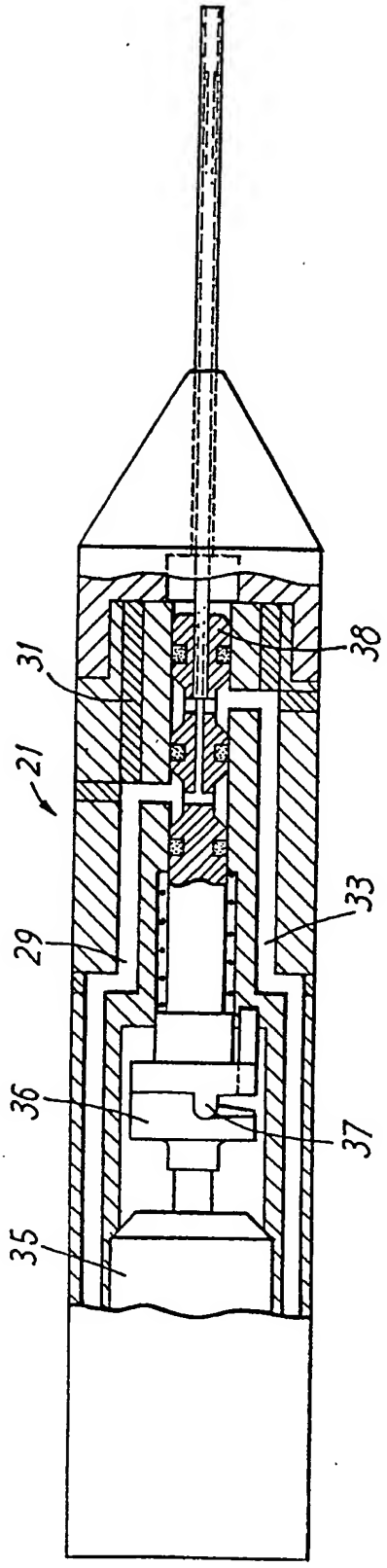

FIG. 8

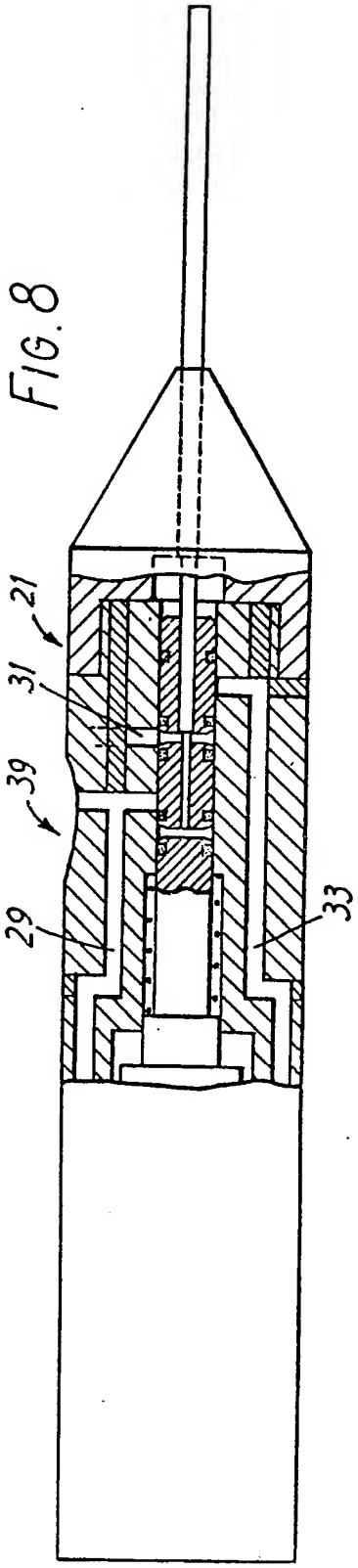

FIG. 9